Remodeling Technique in the Treatment of Intracranial Aneurysms: Indications, Limits and Non-indications

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Introduction

The main factor limiting endovascular treatment of intracranial aneurysms is the shape of the aneurysmal sac, particularly the width of the neck. In 1992, Jacques Moret in Fondation Rothschild (Paris, France) began promoting the remodeling technique [1] that has revolutionized the treatment of wide-necked intracranial aneurysms. This technique involves a temporary inflation of a non-detachable balloon in front of the neck of the aneurysm during each coil placement [2].

The final result consists in a real remodeling of the arterial wall, the coils remaining "molded" around the balloon, even after its deflation.

The technique has been progressively improved with the development of the new balloons and it is now used in many institutions as a routine technique.

The range of balloons used differs by their shape (from oblong to round), their compliance and trackability. Their indications are well defined, depending on the shape of the aneurysm and its relationship with the arterial wall.

Oblong balloon

Oblong or "sausage" shape balloon is used in side-wall aneurysm. Internal carotid or vertebral arteries are the most suitable locations. Basilar tip aneurysms may require the protection of one or both P1 segment, depending on the anatomy and of the patency of the posterior communicating arteries.

This technique thereby extends the spectrum of treatable aneurysms - even distally located (figure 1) - without increasing the risk incurred by treatment [3-6]. Moreover, in case of rupture of the aneurysm during coiling, the balloon can be inflated immediately to stop hemorrhage and allows the placement of another coil to occlude the breach. In this way bleeding is rapidly managed and clinical consequences minimized [7].

Hypercompliant balloon

In order to treat bifurcation aneurysm, the hypercompliant HyperForm® balloon (EV3, Plymouth, MN) has been developed [8]. It differs from the HyperGlide® balloon by a significantly greater compliance, allowing conforming to complex bifurcation aneurysms. When inflated, it may either partially herniate into the neck of the aneurysm or easily change from its cylindrical shape to expand into the origin of the arterial branches emerging from the aneurysm neck. In such a way, the balloon conforms easily to the aneurysmal neck and its surrounding vessel structure (figure 2).

Round balloon

Very wide-necked aneurysms located in the middle of a "T"-shaped bifurcation are unable to be treated using the previously described

Figure 1 A) Ruptured basilar tip aneurysm (AP view) in atherosclerotic patient. B) Remodeling technique with HyperGlide® balloon inflated, allowing deposition of coils within aneurysm sac. C) Post-operative aspect.

technique as an oblong custom made balloon available in the market cannot protect both the neck and the branches of the bifurcation. Such aneurysms are mostly located in the middle cerebral artery and the anterior cerebral artery bifurcations. In such a situation, we currently use complex shape coils (as 3D shape coils) in conjunction with a round balloon placed in the "T"-shaped bifurcation so as to maintain the coils inside the aneurysm. For that purpose, a round latex balloon (n°1, Balt Extrusion®, Montmorency, France) is glued with the help of Glubran® on to a 1.5 French flow-guided microcatheter (for instance, Ultraflow®, EV3, Plymouth, MN) (figure 3).

Strategies

Coil delivery under balloon inflation

Before depositing the first coil into the aneurysmal sac, the non-detachable balloon is inflated in front of the neck, causing the tempo-

Figure 2 A) Left unruptured MCA broad-based aneurysm. Working projection and 3D view. B) Strategy consists in a remodeling technique that utilizes a HyperForm® balloon placed from M1 segment towards the M2 segment. Thanks to its great compliance, bulging of the balloon during inflation will protect patency of the side branch that arises from the neck of the aneurysm.

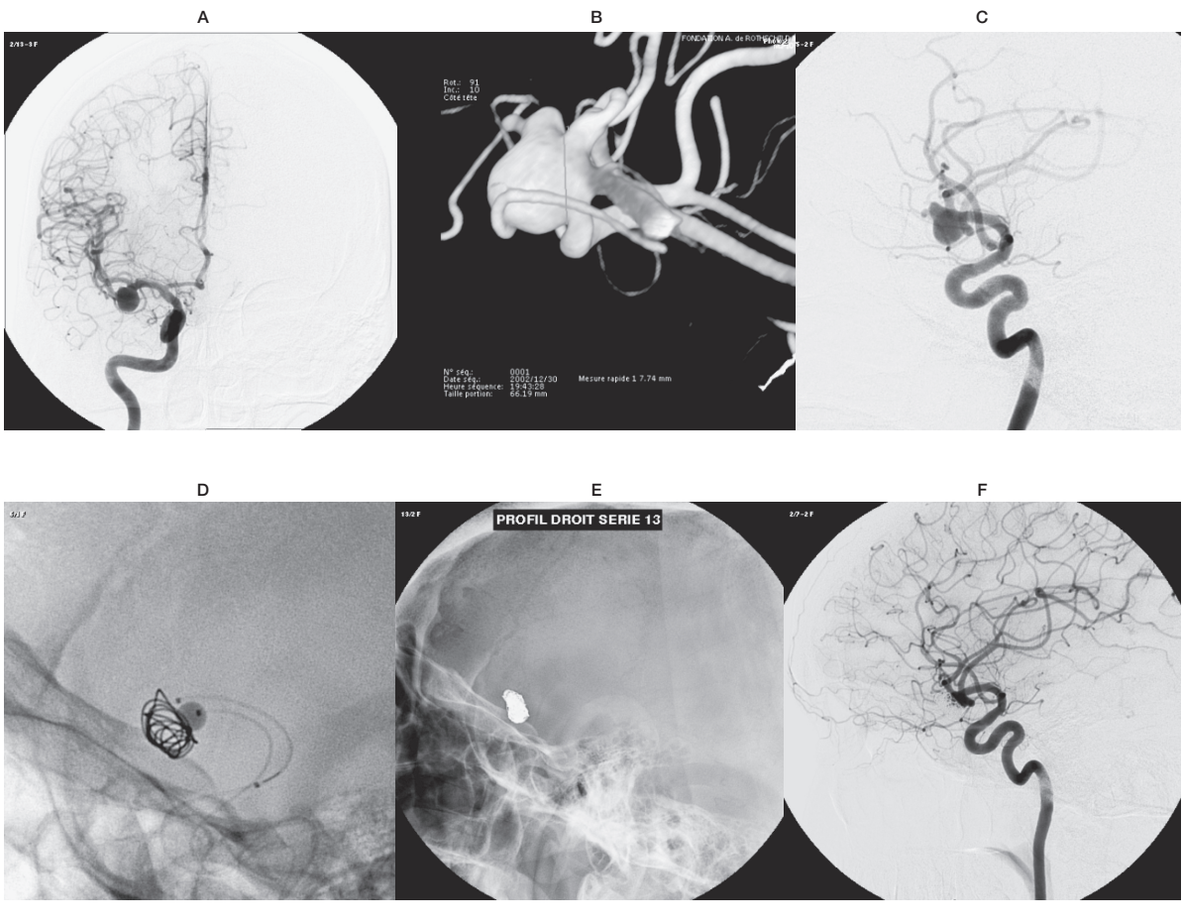

Figure 3 A, B, C) Non ruptured broad-based right MCA aneurysm. AP view (A), 3D view (B) and working position (C). Note that the aneurysm is located on a T"-shaped bifurcation. Due to the very large neck, remodeling technique has been planified, utilizing a round latex balloon (Balt N°1) glued onto a flow directed catheter (UltraFlow®). D) Round balloon is inflated in front of the neck of the aneurysm, allowing deposition of a 3D coil. Further coils are then added, thanks to the round balloon that maintains in place the 3D cage. E, F) 3-months follow-up angiography confirms the perfect exclusion of the aneurysm.

rary occlusion of both neck and parent vessel. In such a way, the balloon follows the contour of the parent artery and covers the origin of the neck. Thus, it is possible to bridge the neck and create a basket with the first coil within the aneurysmal sac [9].

The balloon occlusion should not last more than 5 minutes [10]. After the first coil is positioned, but before detachment, the balloon is deflated in order to test the stability of the material into the sac. If no displacement of the coil is observed, the coil is detached.

Placement and stability of the first coil is crucial. If however, there are undesirable changes in the coil position, it is retrieved and another attempt is made, either with the same coil or with a coil of a different diameter.

Each time a new coil is introduced, the balloon is inflated and the same procedure is performed. Control angiograms are performed during and at the end of the procedure.

Retrograde approach

Generally, the approach to aneurysms is anterograde, with both the microcatheter for coil introduction and the balloon catheter for neck protection or stenting entering via the parent vessel feeding the aneurysm. However, some-

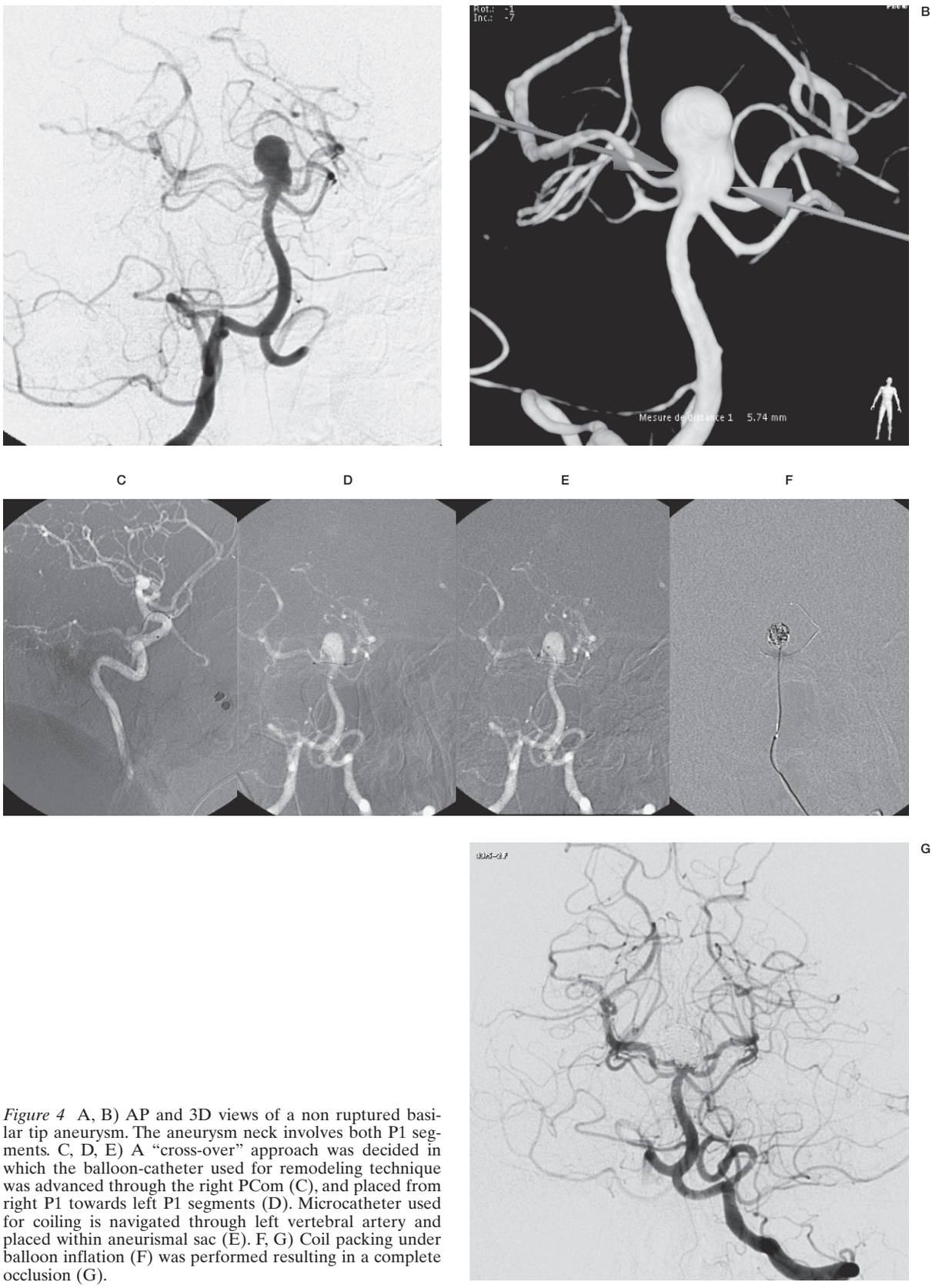

Figure 4 A, B) AP and 3D views of a non ruptured basilar tip aneurysm. The aneurysm neck involves both P1 segments. C, D, E) A "cross-over" approach was decided in which the balloon-catheter used for remodeling technique was advanced through the right PCom (C), and placed from right P1 towards left P1 segments (D). Microcatheter used for coiling is navigated through left vertebral artery and placed within aneurismal sac (E). F, G) Coil packing under balloon inflation (F) was performed resulting in a complete occlusion (G).

Figure 5 A) Broad based non ruptured left MCA aneurysm. Working view. B) Due to the very large neck, two Hyperglide® balloons were placed within MCA bifurcation. C) Final angiographic aspect after double remodeling technique.

times this anterograde approach is not optimal, either for "remodeling" the neck or for filling the aneurysmal sac. It is possible to access cerebral aneurysms by using an angle of attack to the aneurysm other than the usual anterograde route through the parent artery. This unusual route uses mostly a retrograde approach via a communicating vessel [7,11,12]. In all situations, the aneurysm has to be located on or upstream from the circle of Willis.

Obviously, given the anatomic constraints dictated by percutaneous access to the cerebral circulation from the internal carotid artery (ICA) and vertebrobasilar systems, this technique is not considered for aneurysms of the middle cerebral artery or those beyond the A1 and P1 segments of the anterior cerebral artery and posterior cerebral artery, respectively.

All aneurysms which have an anatomy that dictates an unconventional approach with a microcatheter may be candidates:

• This is usually because a broad base aneurysm is located on a "T" shape bifurcation like basilar tip or ICA termination. In such situations, it is possible to achieve optimal positioning of the remodeling balloon by placing it horizontally across the aneurysm neck, bridging either one P1 to the other (via a PCom approach) or A1 to M1 (via an ACom approach), respectively (figure 4).
• In other situations, we may face an arterial branch adjacent to the aneurysm that needs balloon protection at an angle that is best protected by a non-anterograde approach with the balloon protection catheter.
• Sometimes the technique is chosen for aneurysms that cannot be completely embolized, because the catheter cannot be navigated, via an anterograde route, into a critical part of the aneurysm.

Double remodeling technique

Compared to sidewall aneurysms, bifurcation aneurysms are more challenging from an endovascular standpoint, as well as from a surgical standpoint. For endovascular management, various adjunctive techniques such as remodeling techniques or retrograde approach have been proposed.

The latter technique allows accomplishing the treatment of some otherwise uncoilable aneurysms.

However, this technique requires the communicating arteries to be open. If not, another approach is to place two balloon catheters at the arterial termination in a Y configuration, one besides the other, both beginning proximally in the parent artery and ending distally, one in each of the 2 terminal branches [13, 14] (figure 5).

Results

Several small, monocentric series have analyzed feasibility, safety, and efficacy of the remodeling technique [3-7,15,16] and have shown that the remodeling technique does not increase the frequency of thrombo-embolic events and clinical complications

Thus, despite the use of two microcatheters in the same artery and the repeated temporary inflation of the balloon and subsequent occlusion of the artery, the rate of thrombo-embolic events seems to be less of an issue with the remodeling technique than with normal coiling treatment.

In fact, even if the procedure is more complex, it eliminates the bulging of the helix of the coil inside the parent vessel. Moreover, in case of rupture of the aneurysm during coiling, the balloon can be inflated immediately to stop hemorrhage and allows the placement of another coil to occlude the breach. In this way bleeding is rapidly managed and clinical consequences minimized [7].

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